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SIMULATION OF OPTICAL COMMUNICATION BY USING WIRELESS SENSOR NETWORK FOR MODE-DIVISION MULTIPLEXING

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ABSTRACT

Wireless sensor networks play a major role in monitoring and control in industrial sectors. The evolution towards the information-oriented world, the demand for data capacity and transmission quality has also increased. There are many advantages of using WSNs including less energy consumption, reliability, and so on. In Optical communication, an MDM is the biggest challenge to reducing a crosstalk using a wireless network. This will include basic concept of Optical communication, components, and its advantages. Optical communication is widely useful in telecommunications systems networking and data processing. In this paper a design of WSN for mode-division-multiplexing is proposed to improve the overall capacity of the network. A comprison has been mode between the two channels of WSN-MDM at different different FSO length. We have taken two channels and five different length values of FSO channel that is at 500, 600, 700, 800, 900 meters.

KEYWORDS: Wireless Sensing Networks (WSNs), Optical communication, MDM, Signal-to-noise ratios and bit error rates.

I. INTRODUCTION

1.1. Optical communication

Optical communication is the type of communication which uses light to transfer the signal from transmitter to receiver end, rather than electrical current. The main components of Optical communication are transmitter or receiver, modulator or demodulator, a light signal and a transmission channel. It consists of the transmitter to transmit an optical signal, a channel to carry the signal and a receiver which receives the optical signal. Optical communication depends on optical fibres to transfer signals from the source to destination. As a result of its various points of interest over electrical transmission, the optical communication system has to a great extent overpowered copper wire communications in essential networks in the world. Optical communications systems try to address the constraints of radio frequency communications.

1.1.1. Components of Optical communication system

Optical communication systems comprise of the be components:

- **Transmitter:** The transmitter or source end converts an electronic signal to light signal and transmits it to the receiver end. The most common transmitters which are used are semiconductor devices, for example, laser diodes and light-emitting diodes (LEDs) and laser diodes.

- **Receivers:** Receiver or destination typically comprise of a photo-detector. The photo-detector is a semiconductor-based photodiode which changes over light signal into electrical signal utilizing the photoelectric impact.

- **Optical Fiber:** Optical fiber comprises a cladding, core, and a buffer by which the cladding directs the light signal to the core by utilizing total internal reflection.

1.1.2. Advantages of optical communication:

Optical communications have several advantages; some of them are listed below:

- The primary advantages of optical communication incorporate high data transfer capacity or bandwidth, very low rates of losses, no electromagnetic interference, and broad transmission range.

- Optical communications have much higher transmission capacity, high bandwidth which means they can transfer more information, enabling users to send more information to receiver end.

- Optical communications range has not been controlled, so the user does not have to stress over available locations.

- Optical communications systems are much lighter, smaller and consume less power as compared to radio frequency systems.

The limitations of optic communication system incorporate the high cost of transmitter/receiver, cable and other equipment, and the need of expertise and skill during installation and interconnection of cables.

1.2. Wireless Sensor Networks (WSNs)

Nowadays, an effective design of a Wireless Sensor Network (WSN) has become a main area of research. A Sensor is an instrument or device which detects some kind of signals from physical as well as from environmental conditions, for example, heat, pressure, light, and so on, and responds accordingly. The output of the sensor is, for the most part, an electrical signal which is transmitted to a controller to be processed further.

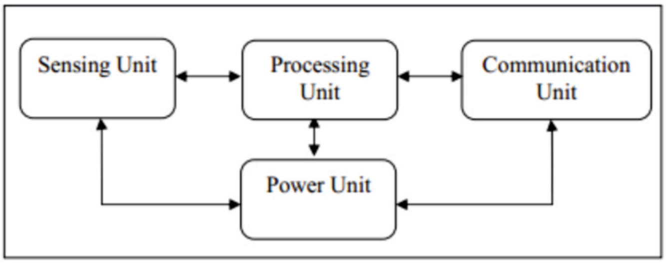

Figure 1: Block of sensor node diagram

A Wireless Sensor Network is a distributed system, and it involves a huge amount of distributed, self-coordinated, low powered, small devices called sensor nodes. [2] WSN envelops countless scattered, petite, battery-operated, installed devices which are connected to collect, process, and transfer information to the users, and it has limited computing and processing abilities. Remote sensor nodes are consisting of sensing unit, a processing unit, power unit, and communication unit. Each node is proficient in performing information gathering, sensing, processing and interacting with different nodes. The sensing unit detects the surrounding, the processing unit calculates the bound stages of the detected information, and the communication unit performs transfer of processed data to the neighboring sensor nodes.

1.2.1. Application of WSNs

- WSNs are utilized as a part of environmental tracking, for example, animal tracking, forest detection, flood detection, weather prediction and forecasting, and furthermore, in business applications like seismic exercises forecast and observing.

- The most as often as possible utilized WSN applications in the area of Transport systems, for example, observing traffic, element routing management and checking of parking areas, and so forth. utilize these networks.

- Health applications, for example, Tracking and checking of patients and specialists utilize these networks.

- Military applications, for example, Enemy tracking, monitoring environment as surveillance applications, security detections, utilize these systems. The sensor nodes are released to the field of intrigue and are remotely monitored and controlled by a user.

1.3. Mode-Division Multiplexing in Optical Communication

Mode division multiplexing (MDM) is a multiplexing approach proposed as a technology to address future transfer speed issues and has been effectively exhibited in free space utilizing spatial modes along with orbital angular momentum (OAM). In MDM based communication networks, every spatial mode, from an orthogonal modular source, could transfer a free data stream, in this manner expanding the overall capacity by a variable equivalent to the number of modes utilized. More degrees of freedom are needed to frame a thickly stuffed mode space to enhance the information transmission rate further. Hence, the proposed mode-division multiplexing procedure in optical communication in view of OAM modes is exceptionally encouraging for expanding the capacity of optical communication systems in a power-saving effective technique, without the powerful utilization of modular de- multiplexing misusing real-time electronic processing.

II. RESULTS AND DISCUSSION

The proposed model is designed in OptiSystem, and better results are obtained. We have a circuit for two channels that are for channel 1 and channel 2. In this, we have two parts; one is the Transmitter part, and another is the Receiver Part. In the Transmitter part, we have used, Pseudo Random bit sequence to generate the bits, NRZ Pulse Generator, Mach-Zehnder Modulator, and Spatial CW Laser. In the receiver side, we have used Gaussian optical filters, photodetectors, Lowpass Filters. Between transmitter and receiver circuit we have used FSO (Free Space Optics) Channel. The output will depend upon the range (Length) of the FSO channel. For visualizing Outputs, we have used Oscilloscope Visualizes that are used to view the output of the transmitter part.

To visualize the overall output of the circuit, we have used two BER (Bit Rate Error) Analyzers. These analyzers will provide us the overall information of all its iterations at 500 meters, 600 meters, 700 meters, 800 meters and 900 meters respectively. It will also represent the Eye Diagram for all the Iterations. At the output, we have two BERs for two channels.The output of the overall depends upon the length that is a range of the FSO Channel and the bit rate.

MDM model based upon FSO Channel

Model is as shown in figure 4. In this model, first, the output of spatial CW laser is given to the MZM modulator. CW laser stands for Continuous Wave Laser; it is the type of Laser which produces continuous and an uninterrupted beam of light which has ideally a very stable output power. MZM Modulator stands for Mach-Zehnder modulator; it is a kind of modulator that has a similar structure like a Mach-Zehnder interferometer (MZI).

By changing phase shift of the modulator's arms or, we can say that by applying an electrical voltage to them, the output signal can be modulated. MZM modulator is provided with the input of NRZ also.

NRZ input is the output of the Pulse data. NRZ stands for Non-Return-to-Zero. When the pulse remains same throughout the bit slot as well as its amplitude does not get effected that is it does not drop to lower bit between the two or more than two successive bits.

The MZM modulator's output is further givento the FSO Channel. FSO stands for Free Space Optics. The transmission of modulated infrared beams through the atmosphere to get optical communicationis referred as FSo (Free Space Optics) Communication. FSO channel length is varied between 50 to 900 meters. We obtained the results at FSO Channel lengths of 500, 600, 700, 800, 900 meters. FSO output is given to the Spatial Optical receiver and for visualizing the final results we have taken BER analyzer in which we can obtain the Eye diagram, Q factor values, Minimum BER values, Power values and Threshold values for two channels channel 1 and channel 2 at different FSO length of 500, 600,700,800, and 900.

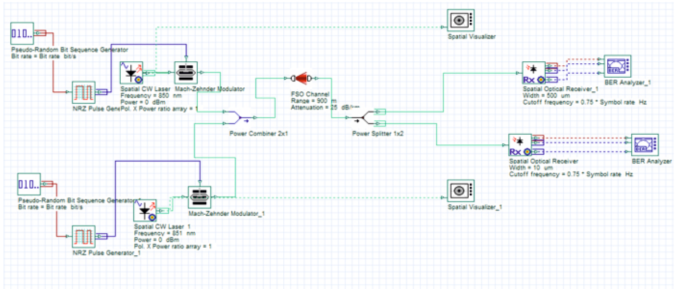

Figure 2: Model designed in Optcal systemOutput values

The below output values are of channel 1 and channel 2 at FSO channel range of 500, 600,700,800, 900. The output table represents the value of Maximum Q factor, Minimum BER values, Total Power and Threshold values for both the channels. The best results are obtained when the Q factor values are as maximum as possible, and BER values are as minimum as possible.

Table 1: Output values of Channel 1 and Channel2

	Channel 1				Channel 2			
FSO Range	**CH1-Max. Q. Factor**	**Min BER**	**Total Power**	**Threshold**	**CH2-Max. Q. Factor**	**Min BER**	**Total Power**	**Threshold**
500	3.64026	0.000136006	-113.15	5.75E-08	3.63831	0.000137043	-108.896	9.17E-08
600	3.67785	0.00011746	-119.709	2.90E-08	3.67844	0.000117185	-116.05	4.27E-08
700	3.51659	0.000218537	-124.442	1.78E-08	3.51716	0.000218065	-121.75	2.35E-08
800	3.63619	0.000138169	-127.176	1.34E-08	3.63607	0.000138237	-125.504	1.59E-08
900	3.74543	9.00E-05	-128.694	1.15E-08	3.74401	9.05E-05	-127.826	1.26E-08

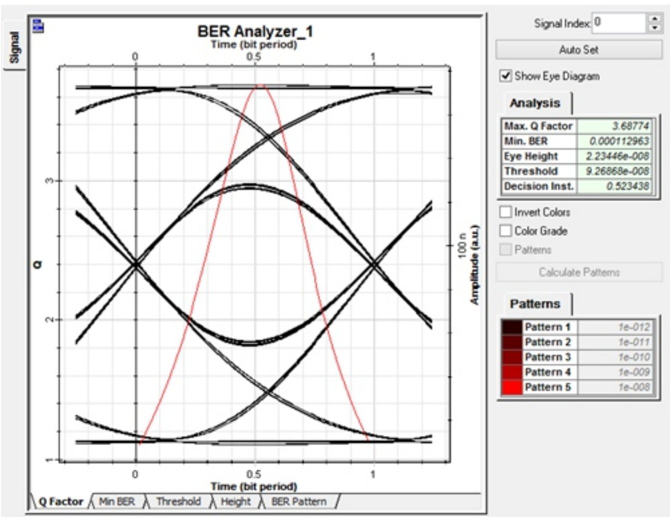

Figure 3: BER analyzer output at FSO Length of 500 meters

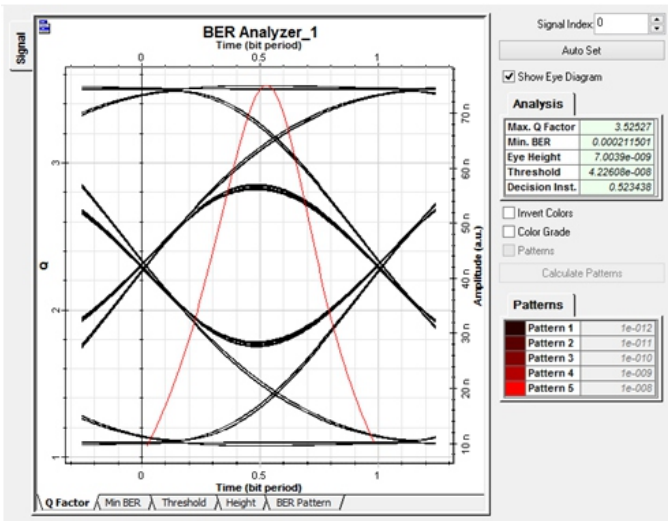

Figure 4: BER analyzer output at FSO Length of 600 meters

The above five BER analyzer diagrams are shown for the different length of FSO channels. We have taken two channels and five different length values of FSO Channel that is at 500, 600, 700, 800, 900 meters. The BER analyzer is the best analyzer for analyzing the output as BER contains the Eye diagram and various plots like BER values plot, Q factor values plot, Eye height plot, Threshold plot and Power values.

We have used two spatial visualizers, one at the output of the Spatial CW Laser and another at the output of the Mach-Zehnder Modulator. The output of spatial Visualizer is as shown below.

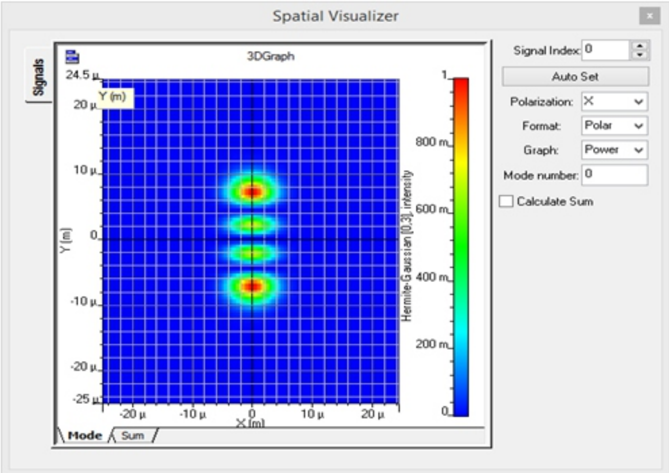

Figure 5: Spatial Visualizes1

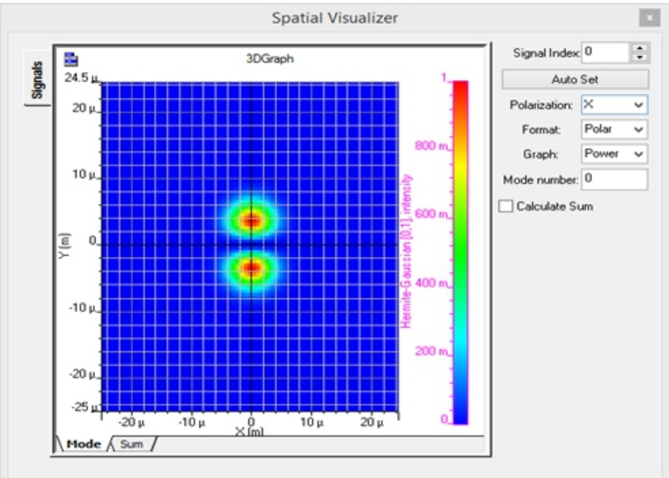

Figure 6: Spatial Visualizes 2

Result Plots

We have drawn the plots of two channels to specify the difference between them as shown below:

1) Maximum Q Factor of two channels

The below plot represents the values of maximum Q factors of two channels with respect to the FSO Channel length of 500, 600, 700, 800, 900 in meters.

2) Minimum BER of two channels

The below graph represents the value of minimum BER values of two channels with respect to the FSO Channel length of 500, 600, 700, 800, 900 in meters.

3) Total Power of two Channels

The below plot represents the total power of two channels in dB m with respect to the FSO Channel length of 500, 600, 700, 800, 900 in meters.

4) Threshold values

The below plot represents the Threshold values of two channels with respect to the FSO Channel length of 500, 600, 700, 800, 900 in meters.

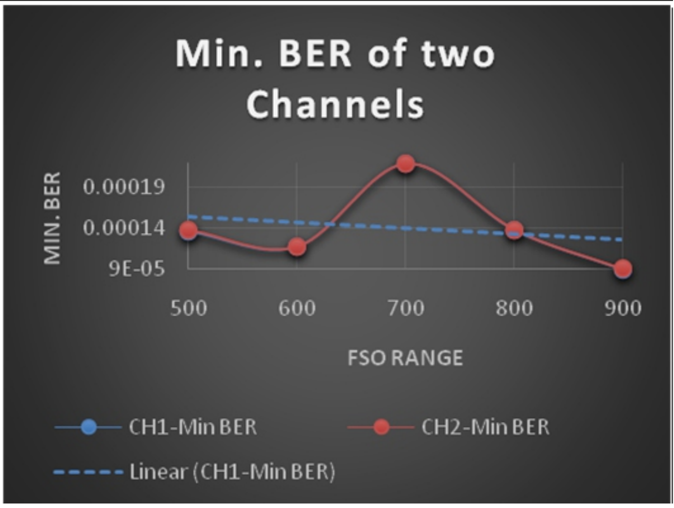

Figure 7: Minimum BER of two channels

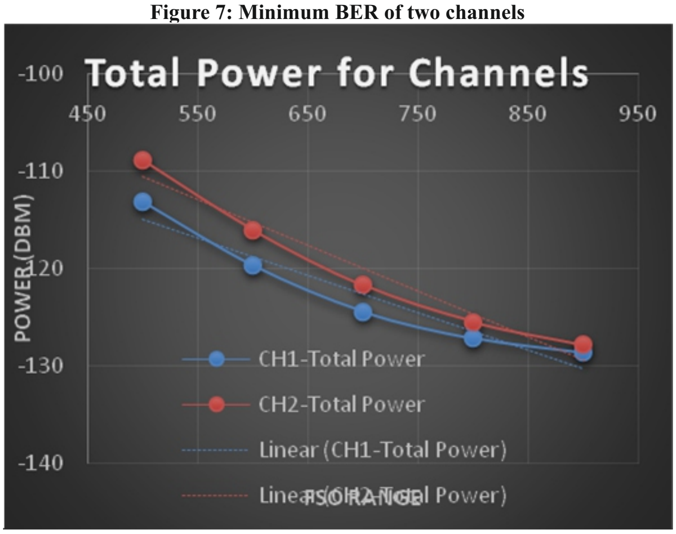

Figure 8: Total Power of two Channels

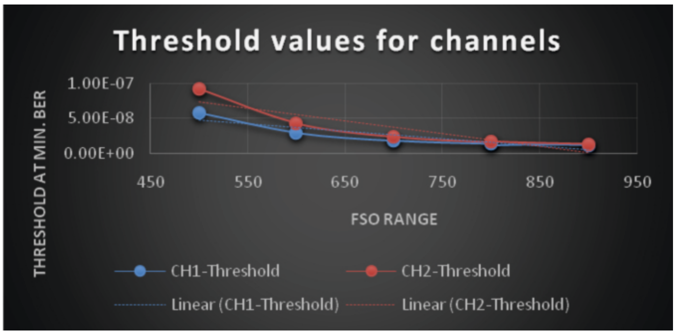

Figure 9: Threshold values

Discussion

In this research, we implemented a design for simulating optical communication using MDM and WSN in Opt system Software. OptiSystem is a software design that enables its users to plan, simulate and test optical links in the transmission layer of modern optical networks. We have generated the eye diagram for the WSN-MDM model. In the WSN-MDM, we used various spatial components like Spatial CW Laser and Spatial Optical Receiver. One FSO channel is also used, the overall output is at different FSO channel lengths that are at 500, 600, 700, 800, 900 meters. We got the output patterns in the spatial visualize as shown above. We have taken the values of Q factor, minimum BER values, Total Power and Threshold values from the above Eye diagrams generated. The results show the improvement over the previous results in terms of increased length and aminimum value of BER (Bit Error Rate).

III. CONCLUSION

This research discussed the techniques used to design Wireless Sensor Networks in Optical Communication. The design of WSN for Mode-Division Multiplexing was proposed with the aim to improve the overall capacity of the Optical communication system. This research also included the comparison of the output of two channels of WSN-MDM model in Optical System using various graphs. By com-

parison the Total Power in the graph no 7, we can say that channel 2 is better than channel 1. The overall results are obtained from the BER visualize that contains the Eye Diagram, Q factor values, minimum BER values, Power values and threshold values of two channels at different FSO channel length.The output of the overall system depends on the length that is a range of the FSO Channel and the bit rate

IV. FUTURE SCOPE

The proposed mode-division multiplexing procedure in optical communication given free-space modes is exceptionally encouraging in future for expanding the capacity of optical communication systems in a power-saving effective technique, without the powerful utilization of modular demultiplexing and misusing real-time electronic processing

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